DOCUMENT RESUME

ED 050 033 SP 004 901

AUTHOR Belgard, Maria R.
TITLE A Systems Approach to the Teaching-Learning Process.
PUB DATE 71
NOTE 9p.; Paper presented at AERA annual meeting, New York, 1971

EDRS PRICE EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS *Educational Research, *Educational Theories, *Learning Processes, *Research Methodology, *Systems Analysis

ABSTRACT

This paper introduces the concept of educational systems analysis, shows how it can be applied to the teaching-learning process, and indicates how the teaching-learning process, as a system, can be optimized by using operations research techniques. The teaching-learning process is viewed as a highly complex learning control system with the purpose of initiating and monitoring the learning process of the students, under optimal systems conditions, until the goal is reached. A block diagram shows the components of the system and their relationships, the input and output variables, and the technology whereby inputs are transformed into outputs. Utilizing an appropriate weighting function for each desired system characteristic, e.g., entry behavior, subject matter, teaching skills, time schedule, etc., a set of weighted system functions are obtained which can be used to optimize the system. The mathematical model can be applied to one individual or a whole school system, that is, it is general, but the values of the parameters depend on the particular situation to which the learning control system is applied. (Author)

ED050033

C49

A SYSTEMS APPROACH TO THE TEACHING - LEARNING PROCESS

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

Maria R. Belgard

School of Education
Stanford University

64 A Escondido Village
Stanford University
Stanford, Calif. 94305

To Division C

C49

SP004901

A Systems Approach to the Teaching-Learning Process:

Modern educational technology such as computer-assisted instruction, educational television, microteaching, and research conducted on grand scales in Research and Development Centers, in Educational regional laboratories, and in experimental learning labs, have changed the actual teaching practices in today's classrooms very little. Why is this so? Is it because we don' t have a teaching science? Is it because the teachers don't know their job properly? Or is it because there has not been enough time for applying the results of the latest research which could or should really make a difference?

We don't know, we can only speculate. But one thing we do know, that the traditional approaches, even in new settings, can neither meet the chalenge of modern technology nor can they cope realistically with the complexity of the educational process.

I shall, therefore, introduce some powerful new concepts and methods which will permit us to formulate and analyse a number of problems which cannot readily be discussed along traditional lines. In particular, I shall discuss the concept of educational systems analysis, its application to the teaching-learning process, and I will indicate how the teaching-learning process, as a system, can be optimized by using operations research techniques.

Systems analysis is the opposite of partial or piecemeal analysis. Systems analysis deals with a complex problem and sorts out its factors, it examines the relevancy of objectives, determines constraints under which the system has to operate, and estimates costs and benefits of an optimal solution and possible alternatives by building and manipulating a mathematical model of the system. A system is defined by its purpose, the systems elements and their relationship. The elements and their relationship vary according to the purpose of the system. Each system has input and output variables and a technology whereby inputs are transformed into outputs.

Purely analytically, we conceive of a system as a state vector x(t), and a rule for determining its value at a certain time t. Each component of the system x(t) measures a different property of the system. Let us identify the different elements of the system by subscripts 1 to N, such as $x_1(t)$, $x_2(t)$, ... $x_N(t)$. The number N is called the dimension of the system.

$$x(t) = \begin{pmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_N(t) \end{pmatrix} \qquad 1$$

Most educational systems, such as the learning control system, change over time. Changes over time , called transformations, are described by mathematical functions that relate predictively the inputs to the outputs. We have, therefore, a transformation of the system from one state to another. Let x(t) represent the initial state of the system, $x(t_1)=Tx(t)$ the state one time unit later, and,generally x(t), $x(t_1)$, $x(t_2)$..., $x(t_n)$ where $x(t_0) = x(t)$, $x(t_{n+1}) = Tx(t_n)$, n=),1,2,... represents the time history of the system observed at the discrete times n =), 1, 2, ..., the successive states of the system. A simple block diagram gives a visual representation of the system transformation .

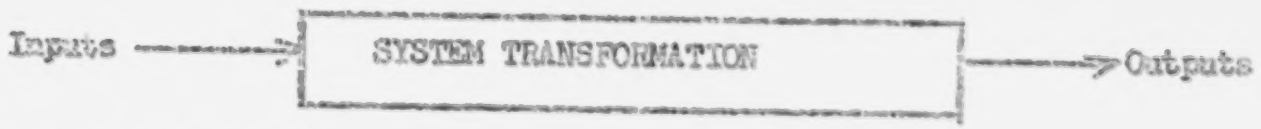

Fig. 1 The system transformation (summarized)

The definition of a block is operational or behavioristic. We do not ask, in ultimate detail, how a transformation takes place, but rather observe that it takes place. If the input-output relationships observed are sufficiently stable, reliable predictions can be made. If no predictable relationship can be measured, the block transformation cannot be defined.

The teaching-learning process can be viewed as a learning control system in which the final performance depends on the efficient interaction of the system elements. The system has the ability to control the learning process of the student through the information it collects about the student's performance on the task. The information about the students learning progress is fed back into the system and the feedback loop continuds to operate until the curriculum is adapted to the individual needs of the student, i.e., until the system's purpose is fulfilled.

The purpose of the system is to initiate and monitor the learning process of a learner until he has learned a task under optimal systems conditions. In other words, the system deals with 'Who learns What, How, When, at what Cost?'. The block diagram (Fig.2) shows the elements of the teaching-learning process and their relationship.

Insert Fig.2

The elements of the system can be classified, according to their relationship to each other, into inputs, intermediates, and outputs. To the inputs belong Entry Behavior E, Developmental Level D, Learning Process L, Subject Matter K, Teaching Skills S, Technical Aids A, Cost C, Time Schedule T, and UncertaintiesU. To the intermediates belong Specification of Performance Objectives PO, Selection of Teaching Strategies TS, Teacher Behavior TB, Learner Behavior LB. To the outputs belong Performance Analysis PA. On the basis of information obtained from the inputs, the performance objectives and the teaching strategies, an optimal and a specified number of alternatives for each, are selected according to an optimization rule. Now the teacher, either live or computer, does the actual teaching, that is, he engages in teacher behavior using the optimal first and changing to alternatives whenever the learner's performance, that is, learner behavior, makes it necessary. The performance analysis is a major analysis which is usually done after the learner has completed the course, but it can be called into operation in emergency conditions such as dropout or changing to another course. The performance analysis is stored and can be used to update inputs whenever necessary.

Concerning the relationship among the elements of the system, we adopt the following conventions: (1) The definition of a block, such as Entry Behavior E, is operational or behavioristic, that is, we do not ask in ultimate detail how it takes place, but rather observe that it takes place; (2) all variables leaving a block carrying the variables at the block; (3) the value of the variable at the block is the sum of all the transformed variables entering that block from incoming arrows; (4) the transformed variable at the point of an arrow head is equal to the variable at the arrow tail; (5) An arrow emerging from block, i.e., E and entering block , PO will signify that E affects PO, E precedes PO, or E's output is an input to PO, etc. Conversely, an arrowhead entering block PO from E, will show that PO is affected by E, PO follows E, or PO's inputs are E's outputs, etc.; (6) the system is closed, that is, the outputs of the system update the inputs of the system until the purpose of the system is achieved.

According to the situation, some systems may want to optimize performance of students, i.e., transfer and/or retention, others may want to optimize time and/or cost, and others may want to test a new curriculum,i.e., a new subject matter. The overall systems conditions are specified according to these priorities. Utilizing an appropriate set of weighting functionsfor each desired system characteristic, a set of weighted system functions are obtained which can be used to optimize the system functions.

The appropriate weighting functions for entry behavior, developmental level, learning process, subject matter, technical skills, technical aids, cost, time schedule and uncertainties are denoted by W_E , W_D , W_L, W_K, W_S, W_A, W_C, W_T, AND W_U, res pectively. The factor W_U is included to account for uncertainties. The weighting functions can be made to have the adaptive characteristics of time variables, i.e., one may increase and another decrease over time. It is from the output of the process illustrated in Fig. 3, and denoted as the overall wiighted system function W_O, that the system specification can be formulated.

Insert Fig.3

After having defined the system and its purpose, the mathematical model can be built. The mathematical model must constantly compare the ideal system characteristcs with the actual system characteristics to obtain the real system characteristics or the optimal solution. The ideal system characteristics can be thought of as a norm or standard

against which the actual performance is matched and then monitored according an optimization rule. From Fig. 4 we obtain two indices, the Optimal Index

$$O = \frac{e}{E_o} + \frac{d}{D_o} + \frac{l}{L_o} + \frac{k}{K_o} + \frac{s}{S_o} + \frac{a}{A_o} + \frac{t}{T_o} + \frac{c}{C_o} + \frac{u}{U_o} \qquad 1$$

and the Ideal Index

$$I = \frac{E_o}{E} + \frac{D_o}{D} + \frac{L_o}{L} + \frac{K_o}{K} + \frac{S_o}{S} + \frac{A_o}{A} + \frac{T_o}{T} + \frac{C_o}{C} + \frac{U_o}{U} \qquad 2$$

The optimal index gives the ratio of actual performance to the optimal performance, that is, it shows how close the system is to the optimal. The ideal index gives the ratio of optimal to ideal performance.

When the variables are quantified, the restrictions or constraints on the variables are stated, and the purpose of the system is clearly defined, the mathematical model allows each system characteristic to be manipulated until an optimal and a certain number of alternatives are found.

The performance of the system is a function of the input elements of the system. $P = f(E,D,L,K,S,A,T,C,U)$ 3

This equation can be rewritten in terms of the functional coefficients. The functional coefficient, represented by N_{XYZ} can be a time-variable, discrete, and/or statistical.

$$P = N_{PE}E + N_{PD}D + N_{PL}L + N_{PK}K + N_{PS}S + N_{PA}A + N_{PT}T + N_{PC}C + N_{PU}U \qquad 4$$

The overall optimum system function W_O is the sum of the weighted functions of all systems objectives.

$$W_O = W_E E + W_D D + W_L L + W_K K + W_S S + W_A A + W_T T + W_C C + W_U U \qquad 5$$

The actual performance is given by $p = f(e, d, l, k, s, a, t, c, u)$ 6

It can be rewritten in terms of the functional cc

$$p = N_{pe}e + N_{pd}d + N_{pl}l + N_{pk}k + N_{ps}s + N_{pa}a + N_{pt}t + N_{pc}c + N_{pu}u \qquad 7$$

Through a transformation of the actual performance function the optimal performance function is obtained. $Tp = P_O$ 8

(For the solution see Belgard|Min: A Linear Programming Model for Optimizing the Learning Process, submitted under Division D, 1971 Annual Meeting AERA)

The systems approach deals with the complexity of the teaching-learning process realistically. It estimates costs and benefits of new teaching methods or new technology scientifically. Above all, it makes a concerted research effort possible by, first, identifying the subsystems which are weak, and, then, integrating the research on these subsystems into the overall system objectives.

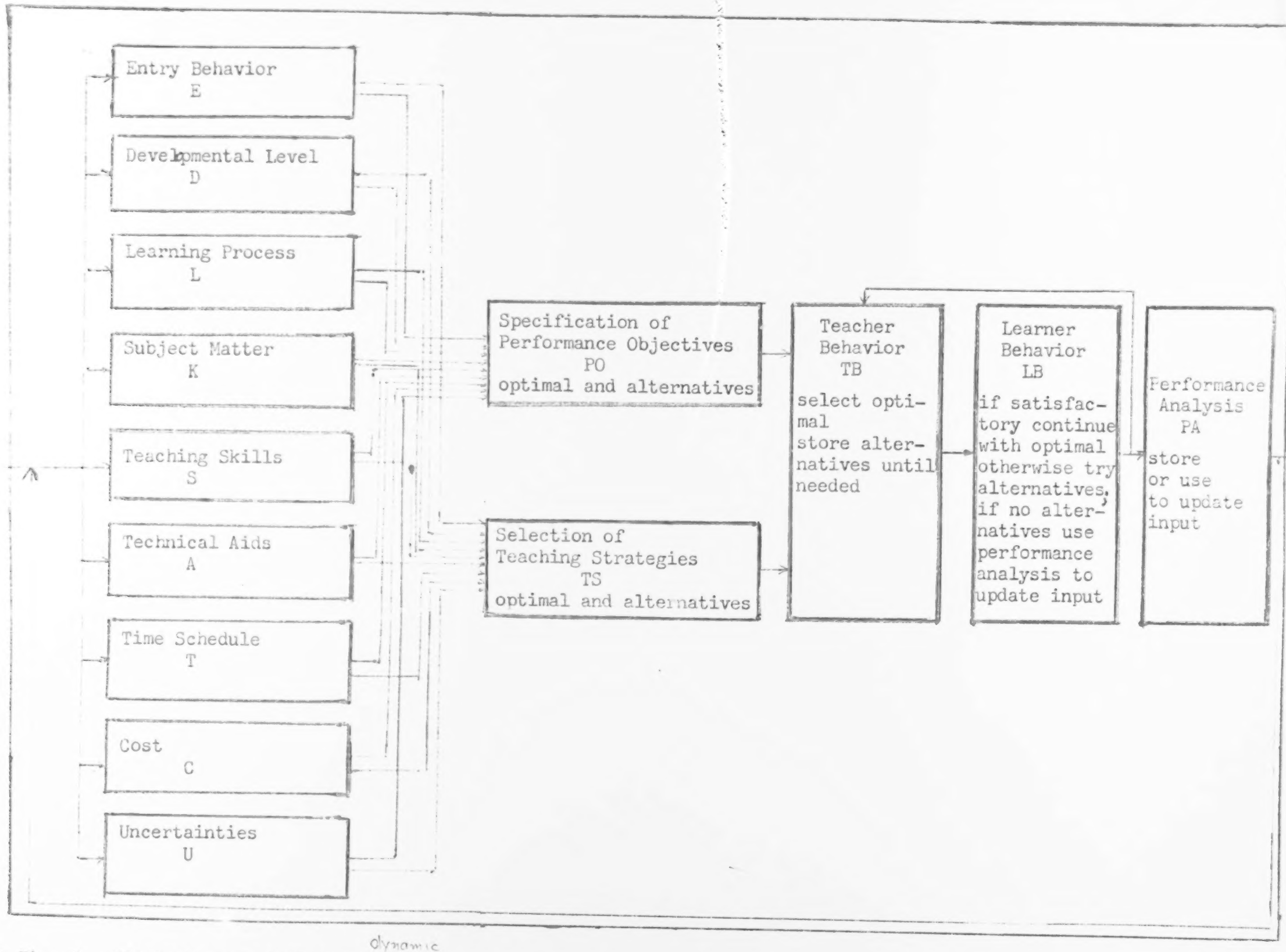

Fig. 2. Block diagram defining the dynamic learning control system, its elements and their relationship (summarized).

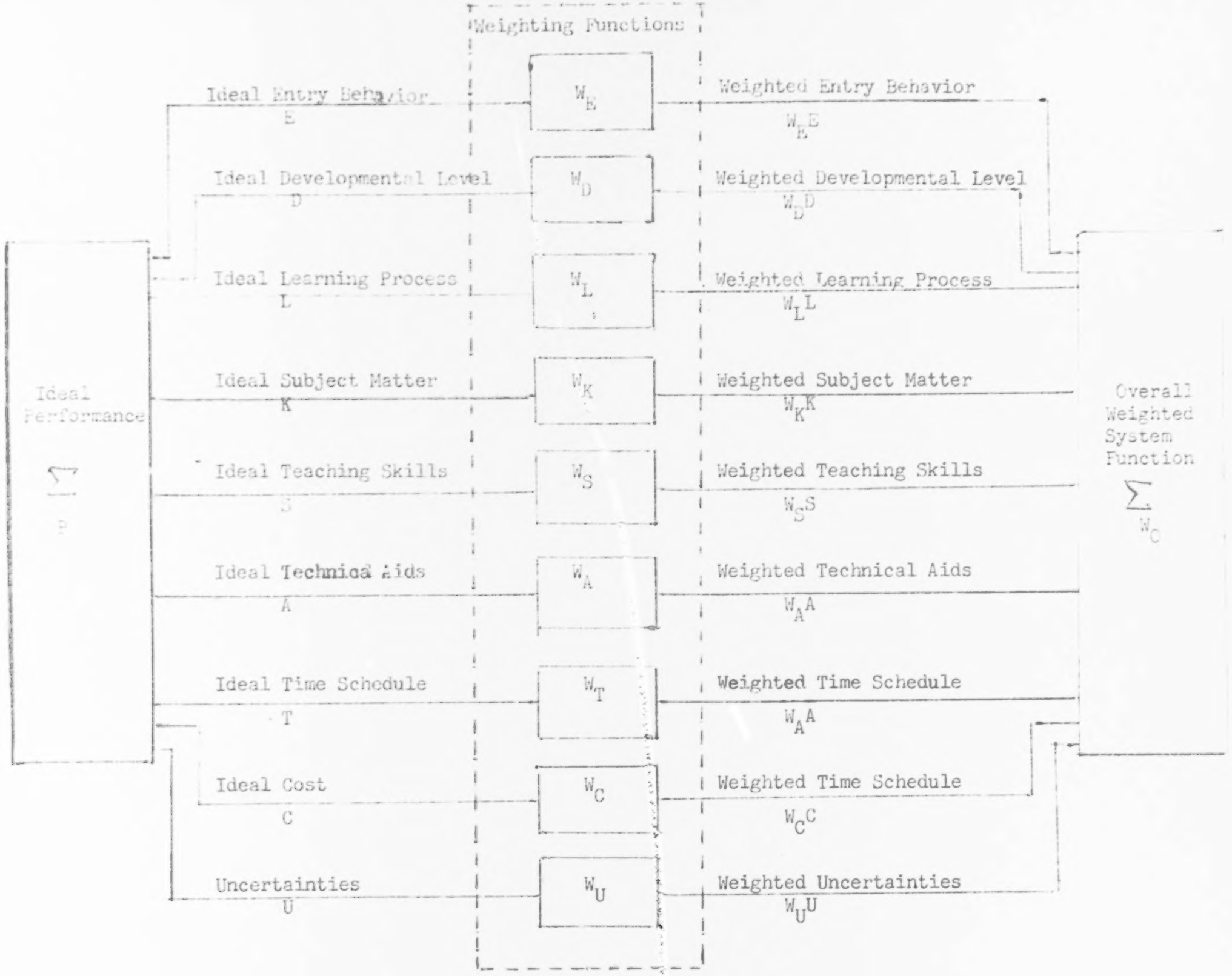

Fig. 3. Block diagram illustrating procedures for optimizing the learning control system. Weighting functions assign priorities to desired system characteristics.

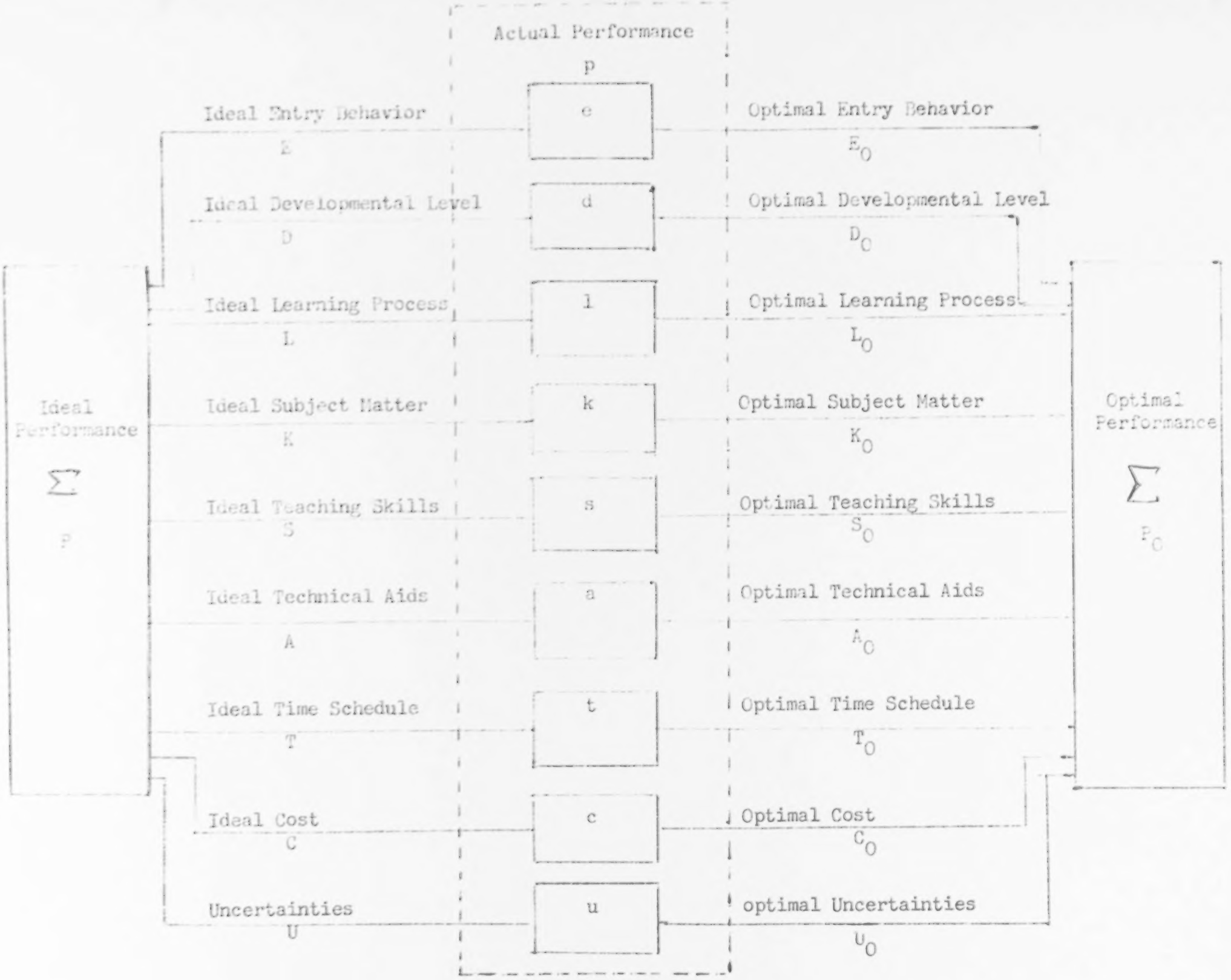

Fig. 4. Block Diagram illustrating ideal, actual, and optimal system characteristics.